37

LAND MANAGEMENT SURVEY

L.M. UNIT 6

ENGINEERING REPORT

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
REGION EIGHT
NAVAJO SERVICE
1937

UNM 1338

NAVAJO SERVICE

LAND MANAGEMENT UNIT SIX

ENGINEERING REPORT

Submitted by:

Allen Stamm,
Engineering Aide

July, 1937

CONTENTS

UNM 1340

GENERAL DESCRIPTION OF THE UNIT

I. Location

Land Management Unit Six known as the "Hopi Unit" is located in the west central part of the Navajo Reservation. The greater portion, or 443,649 acres is in Navajo County with the balance of 55,599 acres in Coconino County, all in Arizona.

The whole of this area was included in the land which was established as an Indian Reservation "for the use of the Hopi and other Indians" by an Executive Order on December 16, 1862. The entire unit has been surveyed by the Coast and Geodetic Service and is marked by section corners.

II. Area and Boundaries

The computed acreage of this area is 499,248 acres. The boundaries are rather well defined and easy to follow in the field since they lie along prominent topographical features as mesa escarpments, washes, ridges, etc. This unit is bounded on the north by Unit Four, on the east by Unit Seven, on the south by Unit Five, and on the west by Unit Three. To quote from the range report: "In most cases there appears to be little livestock movement across the boundaries; however continued friction occurs between the Navajos and Hopis especially in the vicinity of "Blue Point" in regard to range use and it is suggested that a detail study be made of this problem and a definite boundary decided upon."

III. Topography and Elevations

The topography of the northern portion of this unit is characterized by high elongated mesas which are finger-like extensions of the Black Mesa on the north. Between these mesas are found alluvial valleys cut by the main drainages of the Oraibi, Dinnehbitoh, and Polacca Washes. Occasional heads are seen along either sides of these washes; however side drainages and runoff are well absorbed in most places by the extensive and numerous Hopi farms at the toe of the steeper slopes. The southern portion of the unit is less rugged and broken than the northern sections exhibiting a rolling and undulating topography. From west to east the main drainages of the Dinnehbitoh, Oraibi, and the Polacca Washes course in a southeasterly direction. The Dinnehbitoh Wash forms the western boundary of the

unit and lies toward the west of third mesa. The Oraibi Wash is the boundary between first and second mesas; it enters the unit at the northeast corner of Quadrangle 11 and extends approximately 26 miles through the unit; leaving about seven miles southeast of "Blue Point". The Polacca Wash enters the unit on the eastern side along the line between Quadrangles 14 and 13, extending for a distance of about 34 miles before it leaves at the southern end near the middle of Quadrangle 16. The Wepo Wash is the largest tributary to the Polacca entering the unit on the north several miles west of northeast corner of Quadrangle 14, extending southwest between first and second mesas and joining the Polacca about four miles south of Toreva Mission. Keam's Canyon Wash should also be mentioned; joining the Polacca just east of the village of Polacca it is a sizable tributary and heads in Unit Seven. At one time it threatened a number of fields and orchards in the vicinity of the Keam's Canyon Agency.

The elevation varies from about 6,400 feet to 5,400 feet. The elevation at Keam's Canyon is 6,180 feet, at Polacca 5,800 feet, at Oraibi 5,700 feet, at Hotevilla 6,363 feet and at the point where the Dinnehbitoh Wash leaves the unit around 5,400 feet. Elevation of first, second and third mesas and the southern portion of the unit are given on the accompanying climatalogical chart together with other pertinent data. See Page 5.

IV. Agricultural Soils

From the report of the Soil's Branch the following is taken: "The Crown Series is extensively cultivated; its topographic position on the toe slopes of the mesas enables runoff from the steep escarpments to be utilized on small flood irrigation plots. There is a tendency for this series to be drouthy because of the light subsoil. This is particularly noticeable in Sub-Unit I.

The Ives and Concho series have many characteristics in common with the Crown Series. They are located on fans of washes and consequently are irrigated by flood water with little effort. These two series are similar in their heavy subsoil and lend themselves to irrigation only when a light surface soil is present and the subsoil pervious enough to allow adequate drainage.

The Dinnehbitoh and Wepo series are separated on the basis of calcareousness and from a land use standpoint are very similar. These soils will be very satisfactory for agricultural use where sufficient water is available.

The deep alluvial soils have been grouped on a reconnaissance basis as to their adaptability to irrigation and have been given a basic grade on their normal profile characteristics. The factors of erosion, slope, alkali, dispersion, permeability and water-holding capacity modify the basic grade. Susceptibility to wind erosion is not given as much weight in an agricultural consideration as in a range consideration since it is assumed that when adequate irrigation water is applied the vegetative cover and moisture in the soil surface will reduce wind erosion to a minimum.

Local areas of residual soil types are adapted to dry farming; these are generally small and represent so small a portion of the total cultivated area that they are not given specific consideration.

V. Vegetative Types

For all general purposes the vegetation of this unit can be grouped into three major types; grassland, browse, and woodland. All lands types inaccessible, barren, and barren with weeds have been termed waste (see the following table).

Forage Types	Vegetative Types Surface Acres	% of Area	Forage Acres	% of Carrying Capacity
Grassland	169,634	33.98	20,113	45.63
Sagebrush	3,527	.71	385	.87
Browse	257,862	51.66	21,098	47.87
Pinon and Juniper	38,465	7.70	2,482	5.63
Waste	19,356	3.87	0	0
Cultivated	10,404	2.08	0	0
Total	499,248	100.00	44,078	100.00

Some of the most common grasses found are blue grama, galleta, alkali saccaton, sand dropseed, three awn, and spiny muhley. Of the shrubs the more common species are bush mint, chamise, greasewood, mormon tea, shadscale, yellow brush, snakeweed, rabbit brush, salt brush, and parryella. Of the weeds

we find Russian thistle, croton, Colorado bee-weed, and lambs quarter.

VI. Erosion

Wind erosion is active on over-grazed areas of Buell, Todilto, Floy, and Crown soil series and almost universally in the vicinity of farming areas. The practice of breaking and farming a plot for a few years and abandoning it when the light surface soil has been blown away has materially aggravated the wind erosion problem. Grazing on and near concentrated farming areas often starts a movement of sand across a farm that proves very detrimental to cropping. As an extreme example a small dune of moving sand on First Mesa in 1925 has spread to cover an area in 1937 of about 1089 acres and is rapidly extending north and east.

The main washes of the Dinnehbitoh, Oraibi, and Polacca have reached stable bottoms and lateral erosion is only active at the bends and turns. In places caving of the side banks still continues after cloudbursts but a fairly stable width has been reached in most sections.

From these deep and meandering main drainages new side gullies are found. As mentioned under topography and drainage this is due to the fact that most all water is absorbed by the farms situated at the toe of the steeper slopes and mesa escarpments.

Gully erosion in side valleys and draws was not active to an appreciable extent prior to the torrential storms of 1923. During that period deep gullies cut through the stabilized drainageways of the feeder or side valleys and down the toe slopes from the base of the cliffs and escarpments. Since then active cutting has continued except on those few where vegetation has gained hold and tended to bring stabilization.

Sheet and small gully erosion is critical along the east side of the Dinnehbitoh Wash, southwest of the west point of second mesa and east of the Oraibi Wash, along the saccatone draw just south and west of "Badger Butte", in the vicinity of "Burro Springs" and in the northern portion of the unit, particularly along the divide between the Wepo and Oraibi Washes. These critical areas will be discussed under Erosion Control and Waterspreading Projects. (See Cards 4, 5, 5A, 13, 14, 15, 35, 18, 29, 36, 37, 38, 44, 45, 46, 47.)

VII. CLIMATOLOGICAL DATA

Area or Station	Elevation	Avg. Annual* Precipitation	Average Annual* Temperature	Maximum* Temperature
Keams Canyon	6,184	12.43"	50°F	96°
Jeddito	6,150	12.50"	50°F	96°
First Mesa	5,800-6,400	11"-13"	51°-49°	96°
Second Mesa	5,600-6,300	10"-12½"	52°-49°	96°
Third Mesa	5,700-6,400	10½"-13"	52°-49°	96°
Southern Half/Unit	5,400-5,700	9½"-10½"	55°-52°	98°

Table (continued)

Area or Station	Ann. Min.* Temperature F°	Avg. Date* First Killing Frost	Avg. Date* Last Killing Frost	Avg. Lgth.* Growing Season
Keam's Canyon	-12°	Oct. 12	May 27	135 days
Jeddito	-12°	Oct. 12	May 27	135 "
First Mesa	-12°	Oct. 12	May 27	135 "
Second Mesa	-12°	Oct. 12	May 27	135 "
Third Mesa	-12°	Oct. 12	May 27	135 "
Southern Half/Unit	-10°	Oct. 15	May 25	140 "

*All figures except elevations are estimates based upon elevation, vegetation, and the records for Keam's Canyon, Jeddito and Land Management Unit #4 and Unit #5.

VIII. Geology

Mr. Tom Meeks (Junior Geologist) has written a very good reconnaissance of the geology of Unit Six. For a discussion as to physiography and general geology, stratigraphy, cretaceous formations, pleistocene deposits, and landslides see the range report of Mr. W. H. McKinney. Below are included other portions of Mr. Meek's report which the writer feels are more pertinent from an engineering standpoint.

"MINERAL DEPOSITS

Coal

"Commercial coal deposits in this unit are confined entirely to the Mesa Verde formation in the northern part of the unit. The coal occurs in lenses interbedded with shale and is usually thin, 36 inches being the thickest bed measured. The coal seam at Keams Canyon mine is about 8 feet thick but it is made up of alternating thin beds of coal and shales. Another mine in operation at Oraibi was not visited but four to five feet of coal is reported. Coal was observed from Keams Canyon west and in all the mesas in this unit. The limited time available for this report prohibits making an estimate of the available coal or recommendations for future development.

"GROUND WATER

"Ground water in the unit may be divided into two classes, alluvial and formational. The main valleys of the district, the Oraibi and the Polacca have been filled with alluvium to a depth of 100 feet and more and the sands and gravels in them offer a convenient source of water at relatively shallow depths. Minor valleys also offer available water in shallow wells.

"The two formational aquifers of the region are the Mesa Verde and Morrison formations. The dakota is a possible aquifer in the extreme northern portion of the area but it cannot be depended on for sufficient water to justify drilling to the required depth, about 900' - 1,000'.

"The Morrison formation will produce water at almost any locality in the unit with depths varying from 200 feet in the southern part of 1,200 feet in the northern part of the district. Care would also have to be exercised in making well locations in order to provide a sufficient intake area. Abundant water in the Morrison is usually assured at proper locations but it is universally salty, but in most places is suitable for stock and even for human consumption.

"The Mesa Verde forms a source for most of the springs in the unit but is not as suitable for deep wells. The springs are forced out of the base of the sandstones by the underlying impervious shales, and the water from them is practically always good. Blow sand in the unit also forms a source for many of the springs where it rests on a fairly impervious formation.

"ENGINEERING

"The sandstone of the Mesa Verde is one of the most suitable building stones on the reservation and is also suitable for a base in reservoirs but jointing must be carefully studied an impervious foundation is to be obtained.

"The mancos is also suitable for a base for reservoirs if proper precautions are taken. It is second to none in imperviousness on the reservation, but the soils derived from it are heavy and "piping" is characteristic and must be guarded against.

"A few suitable building stones may be found in the Morrison but these should be carefully selected since the Morrison as a rule is weakly cemented and has a tendency to melt when becoming wet. For this reason care should be exercised in using the Morrison as a base for reservoirs, although the silt carried by the stream in this district would quickly seal it."

PRECIPITA TION AND RUNOFF

Precipitation records have been kept at Keam's Canyon for a number of years while a station at Jeddito has been read by the trader there during the last six years. Other records are available for Chin Lee, Kayenta, Winslow, Fort Defiance, St. Michaels, and Tuba City. From this data and estimates made on Units Four and Five a climatological chart has been made for various sections of the unit giving the elevation, average annual temperature, average annual precipitation, maximum temperature, minimum temperature, average date of first and last killing frost, and average length of the growing season. See P. 5

Runoff calculations were made of the Keam's Canyon, Polacca, Wepo, and Oraibi Washes since on these drainages, diversions and irrigation projects were planned or examined. Several Hopi and Navajo informants were queried and showed the writer high water marks along these drainages where large floods in the past left debris lines. Sections were taken at these points and estimates made as to the maximum crest which passed at those times. From this information and data secured from the study on Unit Four and Unit Five four expectance charts have been drawn showing the maximum crest to be equalled or exceeded within any future span in years. (See page 10 .). Number 1 line is for thePolacca Wash below the junction with the Wepo Wash, number 2 for thePolacca Wash above the junction with the Wepo Wash, number 3 for the Wepo Wash above the junction with the Polacca Wash, and number 4 for Keam's Canyon Wash opposite First Mesa. Other estimates of maximum crest and annual expectancy in acre-feet have been made on those farms and special erosion control projects which we thought necessary. These are shown on their respective cards.

EROSION CONTROL AND WATER SPREADING PROJECTS

With reference to the engineering map and numbering of the drainages the conventional system has been used; whole numbers 1, 2, 3, have been assigned to the main drainages of the Dinnehbitoh, Oraibi, and Polacca Washes. Proceeding upstream the drainages on the left are progressively numbered 1.1, 1.3, 1.5 etc. while those on the right are numbered 1.2, 1.4, 1.6. etc. Gullies of any size flowing into the side washes are given one more decimal, then numbered in the same manner so that the first gully flowing into 1.1 from the left is 1.1.1, the second on the left 1.1.3, while those on the right are 1.1.2, 1.1.4, 1.1.6, etc.

Critical erosion control and water spreading areas on Unit Six are shown on Card 5A along a valley south of "Badger Butte", Card 29 east of the Oraibi Wash and four to eight miles west of "Second Mesa, (See Sketch #3.) Cards 35 and 36 along the east slope of the Dinnehbitoh Wash, Card 37, south and east of "Blue Point", and Card 38 in the vicinity of "Burro Springs". These critical areas are very badly overgrazed and serious sheet erosion has begun with gullying present in many places. General treatment will cost from 25¢ to 60¢ an acre and consist of horseshoe water conservation and water spreading dams and dykes, small earth diversion dams and dykes, scattered rock and wire spreaders and small rock drops and checks where heads over 2 1/2' are found. It is suggested that no

work be done on gullies less than two feet deep since we believe that range control will partly stabilize the smaller gullies.

It must be remembered that treatment only in the valleys and on the gentler slopes will be feasible. This cost of treatment will approach $2.00 an acre on land actually treated with indirect benefits to the steeper slopes and rougher land. We feel that since it was impossible to locate each structure this per acre standard was necessary. Many isolated heads have not been seen; these will, however, be treated with money allocated to the entire project.

Semi-critical erosion control and water spreading areas are shown on Cards 4 and 5 southeast of "First Mesa", Cards 13, 14, 15 on the Wepo drainage near the Pinon road, Cards 18, 44, 45, 46, and 47 on either side of the Oraibi at the northern part of the unit. These areas are overgrazed and gullying beginning; however, we hope that range control will allow almost complete recovery and only recommend treatment of the gullies over two feet deep and structures at those locations where spreading ground is excellent.

The balance of the erosion control and water spreading projects should be deferred until later and not treated unless the critical and semi-critical areas have been worked first.

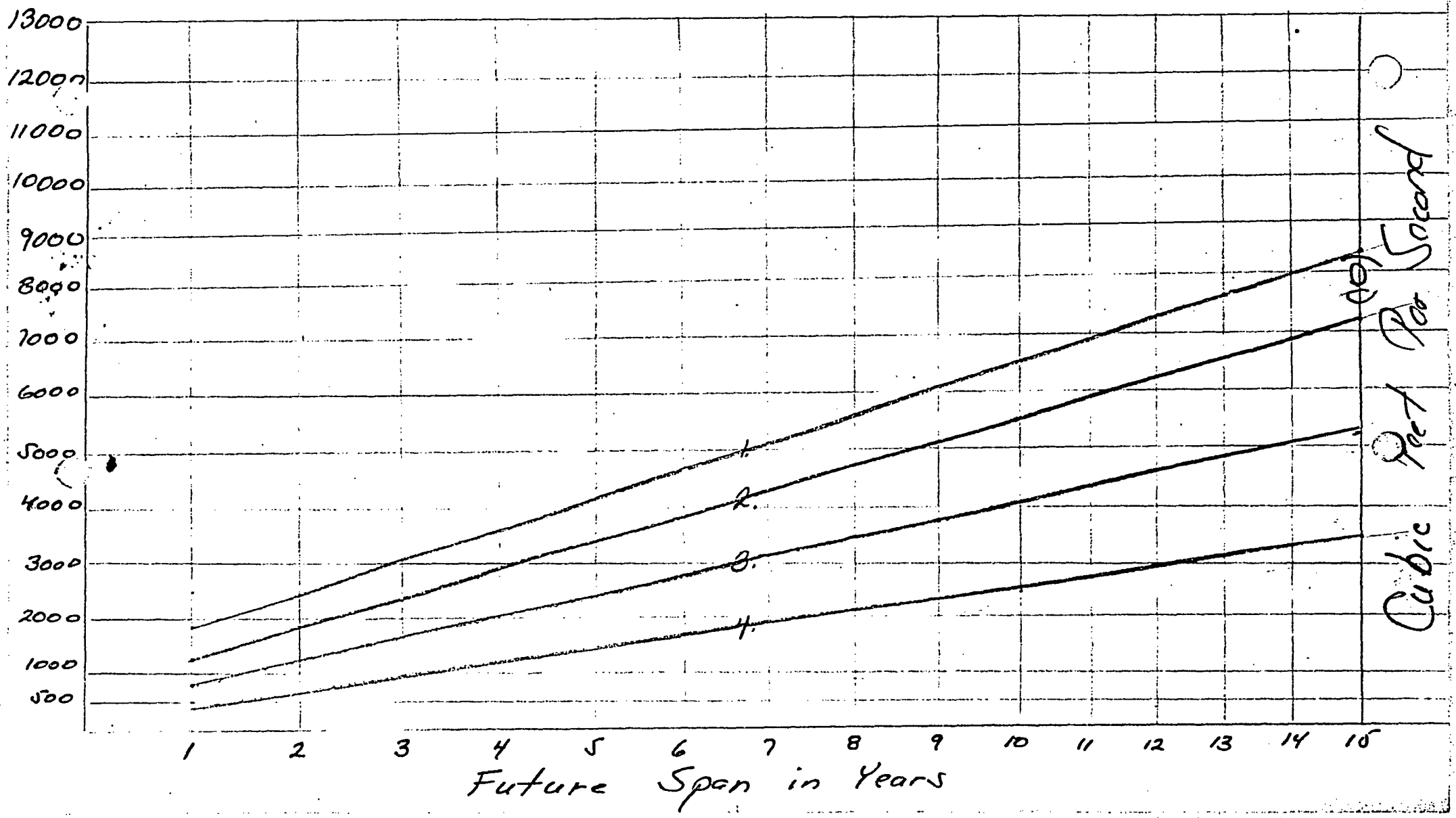
SPECIAL EROSION CONTROL PROJECTS

On the 1" to-the-mile map with this report are shown a number of Special Erosion Control Projects. Themajority are diversions to farms or protection dams and dykes to prevent heads from advancing through agricultural or farm land. In the index this type of development is segregated from the balance of the Special Erosion Control Projects. Some special projects exclusive of the agricultural developments are shown on Card 1, protection of an agency orchard at Keam's Canyon by a rock and wire jetty; Card 22, three lines of windbreaks protecting the new high school at Oraibi from drifting sand dunes; Card 30, a special road job to save 250 acres of range threatened by road erosion; and Cards 7, 24, 32, 34, and 40 protecting range and grass land from head-cutting and serious gullying. In the index are shown those projects which may be classified as critical, semi-critical and secondary under column, "Priority".

1350

Maximum Flood in Cubic Feet Per Second To Be Equalled or Exceeded Within Future Span

1. Polacca Below Junction With Wepo
2. Polacca Above Junction With Wepo
3. Wepo Above Junction With Polacca
4. Keam's Canyon Wash Opposite 1st Mesa.



FARM DEVELOPMENTS AND DIVERSIONS

As mentioned on Page 9 under "Special Erosion Control Projects" the majority of the special projects consist of various types of protections and developments on those farms where water is not being utilized to the fullest advantage. Examples are Cards 2, 10, 17A, 19, 20, 25, 26, 27, 31, 33, 39 and 48. All of these projects have been carefully studied by the agronomist and engineer together and a plan decided upon to utilize the escaping water in the best way possible. On most of the cards subjugation costs are shown; these have been estimated by the agronomist and are incorporated within his report. These figures are in brackets and have the notation "Ag. Report" opposite to emphasize that they are not to be included in the totals shown on the engineering cards.

On the balance of the farms subjugation will handle floods and runoff and little water is expected to be un-used. The agronomist has visited each individual farm and has called the engineer only as a consultant in those cases where diversion structures or protection dykes seem necessary. Often we have assumed that the Indian himself can with shovel and slip handle the smaller work on his individual farm.

PRESENT AND PROPOSED AGRICULTURAL AND IRRIGATION PROJECTS

The Hard Rock Diversion and Irrigation Project located on the Oraibi has been given to the Hopis and is included within Unit Six. About fifty acres were cleared and leveled during the spring of 1937 but nothing planted. Soil is clay loam and clay with a few acres of sandy clay loam. The diversion structure and sluice-gate were revamped and the project is now ready for use. On the Land Management Study of Unit Four we recommend this project be given to the Hopis for the Navajos had full possession of it for a number of years and no development of any sort was attempted.

Proposed agricultural and irrigation projects have been given priority numbers; Card 12 as "A"; Card 42, "A"; Card 42, "A"; Card 6, "B"; Card 23, "B"; Card 17, "A"; and Card 41, "A".

Card 12 is the development of Farm #153 in Quadrangle 14. This is the large farm just to the north of the Pinon-Oraibi highway and about ten miles south of Pinon. During the summer of 1936 the road washed out and was threatened by overtopping in several places. Just south of the highway are several large heads progressing up the valley and endangering highway, farm, and several thousand acres of grass and range land. To protect all of this country we have planned on the expenditure of about $5,200, $3,000 as subjugation costs on 155 acres of present farm land and 50 acres

of expansion with $2,200 allowed to cover the cost of masonry drop structure and dykes on either end. The drop structure will spill excess water to the gully southwest of the farm allowing flows to escape through the bridge without endangering the highway. All of this is shown in more detail on Card 12.

Card 6, Sketch No. 1 is rather extensive agricultural development just south of the junction of Keam's Canyon Wash and the Polacca Wash. Our present plan calls for the subjugation of 165 acres at $15 an acre and the construction of a dyke system as shown on Sketch No. 1. Gully 3.8.2 is at present flowing into several large farms on the south which are very heavy clay and nearly impossible to cultivate. To utilize this water we suggest the construction of dykes No. 1 and No. 2 allowing the development of additional land above present farm #48. Dykes No. 3 and N1. 4 will divert flows toward the lower end of farm 48, but should be investigated more closely before a definite construction plan is decided upon. Should we find in the future that this plan continues to allow an appreciable amount of water to reach the heavy land below where it is not used, we suggest the construction of Dyke 5, which will divert drainage 3.8.4 above Dyke 2 and bring additional land into

use for agricultural purposes. Total cost of this development has been estimated at $4,335 including subjugation at $2,475 which is allowed for in the Agronomy Report of E. A. Nickleson.

An intensive and detailed survey was made as to the possibility of diverting the Keam's Canyon Wash at either point A or point B. (See Sketch #1.) At diversion site A we hoped to utilize the land lying between B.M.39 and 43 but the soil representative, Mr. H. F. Johnson, stated that this could only be called "C" range land and was not suited for agricultural development. Yardage would be about 28,000 in the dam and cost about $6,000, so more than a hundred acres of agricultural land would be necessary to justify the project. We then examined site B and hoped to divert drainages 3.8.2 and 3.8.4 well above Farm 48 and to use water from Keam's Canyon Wash on the farms under present cultivation. Yardage in the complete earth fill diversion dam would be approximately 12,000 with an additional 17,000 yards needed between stations [illegible] Provision would be necessary to prevent excess floods from concentrating again in Keam's Canyon Wash. The most practical method would be to continue flooding land ~~below and possibly concentrating~~ to the diversion across the Polacca nine miles below the junction of Keam's Canyon Wash and the Polacca. We believe that it will be impossible to justify this project at the present time. If in the future agricultural land is at a premium in this vicinity and we can warrant an expenditure of $100 an acre, it may be advisable to again study a diversion of Keam's Canyon Wash either at point B or two miles above at point C. Below C within the dotted circle (see engineering 1"-to-1 mile map) lies about 100 acres of A agricultural land which might justify a diversion at some time in the future.

Card 23 covers diversion of drainage 2.14 benefitting about 50 acres along the east side of the Oraibi Wash. This project lies about one and one-half miles southeast of the village of Oraibi and will cost about $1,800 including $750 for subjugation of 50 acres at $15 an acre. If we see that additional water will be available from this drainage, there is an abundance of good land which may be flooded.

Card 17, Sketch 2 is called the "Wepo Project". At one time the Wepo Wash fanned over this country and about three hundred acres were planted in corn. It was some of the best land in this vicinity and no definite drainage channel

of the wash was present. Short diversion dykes shunted flows in most any direction desired and water was very well utilized over all available land. During the torrential rains of 1923 when heavy precipitation occurred for three days, gullying began at the Polacca Wash below, cut up the Wepo Valley through the corn fields and continued on up the drainage. Since this downpour in 1923 ineffective and temporary dams which soon washed away were thrown across the enlarging wash. About eight years ago the last diversion dam was attempted and since then little land has been utilized with the soil rapidly blowing away and no chance for renewal by silt deposits.

We of Study Party "C" carefully surveyed this vicinity and believe we have found a very feasible project. A proposed plan is outlined on Sketch 2 consisting of a masonry or concrete partial diversion dam, canal diverting 200 to 300 cubic feet per second as shwon on canal alignment 2, several rock and wire stabilizers between the diversion site and the bridge to prevent heads in the Wepo from advancing to the diversion dam and threatening the entire structure. Dykes at the diversion will entail 2,500 yards while a protection dyke around heads near the highway will take about 3,000 yards of earth work. Canal will extend about two miles and handling 250 c/f/s must be about 30' x 2½' at the beginning, diminishing in size until at the end it is four or five wide. The tentative plan suggests turn-out boxes at intervals with several overflow structures to handle flood water reaching the canal from slopes on the northwest. Several small protection dykes may be necessary along the edge of the arroyo to prevent flows from again concentrating in the wash. The agronomist, Mr. E. Z. Nickleson, and the soil's representative, Mr. H. F. Johnson, believe 300 acres can be flooded; these at a subjugation cost of $18 per acre will cost $5,400. Windbreaks will be necessary if extensive subjugation is followed. This is discussed in the planting report prepared by Mr. Gale Monson, biologist.

Cost summary of the Wepo Project follows:

Masonry Partial Diversion Dam - 234 yds.		@ $3.50 -$	820.00
Gunite Placing --------- 175 sq. yds.			100.00
Dyke "A" ---------- 2,500 yds.		@ $ .20 -	500.00
Riprapping ----------			500.00
Two Sausage Stabilizers ----------			1,500.00
Canal 0-00 - 108+00 -------- 10,000 yds.		@ $ .20	2,000.00
Dyke "B" ---------- 3,000 yds.		@ $ .20	600.00
Dykes along edge of wash ----------			500.00
Subjugation - 300 acres ----------		@ $18.00	5,400.00
Total Cost ----------			$ 11,920.00*

*This does not include turn-outs or sluice-gate structure which may be necessary.

The Wepo Project has been given Priority "A" in the index, and we feel that after a study is made as to the needs of the people in this vicinity, it may prove our most practical project. It is hoped that a co-operative plan may be agreed upon with the Hopis donating 50 per cent of the labor cost and hauling all rock which may be needed. This project has been discussed with Mr. Wilbur Perkinson of the U. S. Indian Irrigation Service, who believes it may be included in the 1938-39 program of the Irrigation Service. With the Soil Conservation Service subjugating 300 acres of land ~~there will be left~~ approximately $3,500 must ~~be~~ be spent on canal, turn-out boxes, over-flow structures and protection dykes. Mr. Perkinson believes these costs can be carried by the Indian Irrigation Service. Two sausage stabilizers needed between the diversion dam and the bridge may be built by Hopi co-operative labor with material costs carried by either the Soil Conservation Service or Indian Irrigation Service.

We have not estimated the cost of the possible sluice-gate structure which may be needed at the diversion dam. In this survey we have made a rough estimate only as to the total cost of the project, for with the various tentative plans no accurate estimate would be justified.

Card #41, Sketch #4, known as the Polacca Project, is located approximately three miles south of the Wepo Project, or approximately five miles south of Toreva Mission. Lying south of the Polacca Wash, this project extends from the diversion site two miles above the junction of the Polacca and Wepo Washes to approximately seven miles below the junction of the two washes. Within this area are approximately 3,140 acres. At the upper end of the project are found 1,250 acres of heavy clay with 750 acres of this to be used for desilting purposes and the balance as hay land. South of the proposed hay land, 600 acres of light clay loam, classified as "A" agricultural soil, will be subjugated at a cost of $12 per acre. 1,290 acres of light clay loam extend between the subjugated portion and the lower end of the project. These 1,290 acres might be called a safety factor, which may comprise agricultural, range, desilting, and waste portions of the area. On Sketch #4 dotted lines roughly define the limits of the spreading area, with a dotted line showing the approximate boundary between clay and light clay loam. Mr. H. F. Johnson, the soils representative, believes the agricultural land is some of the finest on the reservation.

A rather detailed reconnaissance has been made of the project with levels run on either side of the Polacca Wash and

the closed circuit tied to the Coast and Geodetic line between Tuba City and Holbrook, which extends from Toreva Mission to Polacca. Using contact prints of this vicinity, 1"-to-the-mile aerial mosaics, handlevel and plane table, the 5' contour intervals were plotted as on Sketch No. 4.

Three possible dam sites were examined, shown at A, B, and C. At Point A we hoped to divert water to either side, utilizing land in the vicinity of Giant's Chair and approximately 1,200 acres of the "A" agricultural portion at the lower end of the project. Soils near Giant's Chair proved to be very heavy, and for this reason the proposed dam at Point A was rejected. At Point B, it is possible to construct a complete earth-fill diversion dam with no protection dykes needed below, since it is at this point that the high ground to the south of Polacca Wash begins. Construction of the dam at this point, however, would allow the flooding of only 2,000 acres. At Point C, which is a proposed site of the diversion dam, a total of 3,140 acres may be utilized as mentioned before.

From the expectancy chart on Page 10 we have estimated, as shown by line 2, that a 10-year probable flood will be 5,500 c.f.s. Designing the diversion dam to handle 5,500 C.F.S., we have provided for the passage of 3,000 c.F.S. to the spreading ground on the south with the balance to spread between the Polacca and Wepo Washes. On Sketch No. 4 we have outlined dykes, 1 to 12 inclusive, needed to prevert floods from concentrating again in the Polacca Wash. Tentative design of the diversion dam comprises 23,000 yards of earth-work. The dykes will amount to nearly 30,000 yards. of earth. It is hoped that by using heavy machinery earth-work will cost not more than 15¢ per yard; in our cost summary, however, we have allowed 20¢ per yard. Breaking banks, a possible core wall, and riprap protection will amount to $1,400.

The grade along the spreading ground varies from .4% to .6%. It will be necessary to provide rock and wire stabilizers if head-cutting begins along the steeper grades. Ten of these have been allowed in the cost estimate at $780.

On the sketch we have shown a masonry drop structure at the lower end of the project with dykes 13, 14, and 15 needed to divert flows to the structure. Since it will be seldom that water reaches this vicinity, we suggest that the drop structure and dykes 13, 14, and 15 be deferred. Should head-cutting begin at the Polacca below the drop structure, this cutting can con-

tinue for a mile before it will be necessary to construct the drop system. (See Sketch No. 4.) Estimated cost of the drop and dykes is $8,550 providing for Weir opening of 150' by 5' to by-pass 2,000 c.f.s.

Mr. Ernest Nicholson, the agronomy representative, has allowed $12 an acre as subjugation of 600 acres of "A" agricultural land. Using tractors and terracers for the bordering, it may be possible to subjugate this land at around $9.00 an acre. It is probable that very little leveling will be necessary, for with a grade of .4% water can easily be handled.

As shown on Sketch No. 4 the total cost will be $29,060 with the drop structure and dykes 13, 14, and 15, or $20,510 should their construction be deferred. To justify the project the range representative, Mr. W. R. McKinney, and the agronomy representative, Mr. Ernest Nicholson, believe the 500 acres of hay land may be worth $10 an acre. With 600 acres of agricultural land at $40 an acre we can justify a total expenditure of $29,000. As mentioned before there are 1,290 acres of additional land which may be used for agriculture, range, desilting, or waste.

From an engineering standpoint this and the Wepo Project have been given priority "A", and as discussed later the needs of the people in this vicinity must be determined before we can know which project is more practical.

Card No. 42, Sketch No. 5, known as the Taylor Springs Project, is located at Taylor's ranch, approximately five miles northeast of the village of Polacca. The Indian Irrigation Service, when drilling a well at Taylor's ranch, struck an artesian flow of 2,500 gallons per hour. At the present time, however, the artesian flow is approximately 1,200 gallons per hour, which might be increased to 1,600 gallons per hour by repairing the casing. This equals 3 to 4 acre-feet per month. According to the water analysis a very high percentage of black alkali is found, which without optimum soil and excellent drainage makes the water totally unfit for agricultural purposes. A careful survey of this vicinity has located some excellent soil approximately one-half mile below the well. 2,400 feet of $2\frac{1}{2}$" pipe will be needed to convey the flow to the better soil. A proposed storage reservoir will be located in the heavy clay to the north of the agricultural area.

Estimating the flow at 1,200 gallons per hour, which is about 3 acre-feet per month, we have compiled the chart shown

on Sketch No. 5. Stock-water usage will be .2 acre-feet per month; evaporation and seepage losses will vary from 1 to 2.5 acre-feet per month. From October and continuing until April, water will be impounded in the reservoir. From April until late September there will be heavy withdrawal for irrigation purposes as shown in the last column of the chart. We must construct a storage reservoir to impound nearly 10 acre-feet to allow the irrigation of 5 acres with each acre receiving approximately 3 acre-feet of water in the six months' period from April through September.

Should we find the artesian flow approaches 1,600 gallons per hour, we may plan on the utilization of 9 acres for truck gardening. However, we will need a storage reservoir impounding 15 acre-feet if 9 acres are to be irrigated. The lower chart on Sketch No. 5 shows the estimated losses, usage and expected supply on hand each month in acre-feet with a flow of 1,600 gallons per minute, or 4 acre-feet per month.

Cost of pipe line will be $840; canal and miscellaneous, $500; and storage reservoir, $1,200 to $2,000 depending on the storage capacity desired. It is probable that the actual material costs will not exceed $150, for donated team work can possibly be secured on the reservoir.

It is imperative, therefore, that an accurate estimate be made of the expected artesian flow after the well is repaired; for with 5 acres under the project the cost per acre will be from $300 to $510, while with 9 acres, the cost per acre will be from $150 to $370, dependent upon availability of donated labor.

In our cost estimate we have not allowed for the construction of a drainage system which will be necessary in the future; for eventually, the soils representatives state, adequate drainage will be imperative. We suggest that this project be carefully examined, for it appears from an engineering standpoint to be quite feasible. (See Soils Report for soil and water analyses.)

ROAD EROSION

At Keam's Canyon an Indian Service Roads Division is located, handling the construction and maintenance of primary and secondary roads of Unit 6 and vicinity. Very little erosion

is found along the primary and seconary roads for this is carefully watched by the maintenance crew. The only serious erosion problem along the better travelled highways is at the north end of Quadrangle 14, where drainage 3.9.21 brings heavy floods to farm No. 153 and has started head-cutting along the Pinon Highway at the south end of this farm. This will be handled as shown on Card No. 12.

Within the critical erosion control and water spreading areas rather serious erosion is found along trails and ungraded roads. We have estimated that construction within the critical projects can control this erosion. Over the balance of Unit 6 very little cutting is found near wagon paths and ungraded trails; for this reason no estimate is made of additional work needed to handle roadside erosion.

AGRICULTURE

Below is shown all agricultural land segregated in A, B, C classifications according to rainfall and flood sources of water supply.

CLASSIFICATION OF AGRICULTURAL LAND*

		Present Farm Land				Expansion		
	Class	A	B	C	Total	A	B	Total
Sub-	Rainfall	1	23	2	26			
Unit	Flood	1,152	218	16	1,386	124	50	174
One	Total	1,153	241	18	1,412	124	50	174
Sub-	Rainfall	209	220	-	429			
Unit	Flood	795	129	13	937	637	13	650
Two	Total	1,004	349	13	1,366	637	13	650
Sub-	Rainfall	243	912	3	1,158			
Unit	Flood	1,807	341	-	2,148	124		124
Three	Total	2,050	1,253	3	3,306	124		124
Grand Total		4,207	1,843	34	6,084	885	63	948**

COST SUMMARY

From the agricultural report by E. A. Nicholson the cost of agricultural developments will be $23,298.00. This represents bordering, leveling, terracing, spreaders, etc. on present and potential farm land and is exclusive of subjugation of Farms #402 and #403, Quad. 7, which are not included in the agronomy report. This figure, $23,298.00, is subjugation costs only and does not represent diversion, protection dykes and costs of erosion control and water spreading as shown in this report. The chart on the following page is taken from the agronomy report.

* From Agronomy Report, Table III.

** Includes Expansion on Agricultural Developments and all expansion figures shown on Engineering Project Cards.

	Present Farm Land				Expansion			
	A	Cost	B	Cost	A	Cost	B	Cost
Sub-Unit 1	465	$ 7,285	10	$180	115	$ 1,950	50	$900
Sub-Unit 2	174	$ 2,121	8	$160	635	$ 7,620		
Sub-Unit 3	359	$ 2,062			90	$ 1,020		
Totals	998	$11,468	18	$340	840	$10,590	50	$900

TOTALS	Acres	Cost
A	1,798	$22,058
B	68	1,240
	1,866	$23,298

For crops raised, farming practices, yields, suggested crops etc., see agricultural report by E. A. Nicholson.

In the index (Page 31) is a complete segregation of all engineering and subjugation costs as to sub-areas and types of projects, whether Erosion Control and Water Spreading, Special Erosion Control, or Agricultural Projects. A brief summary of these costs follows:

Erosion Control and Water Spreading		$39.140
Special Erosion Control:		
Subjugation	$4,147	
Diversions, spreaders, etc.		$ 4,005
Agricultural Developments:		
Subjugation	$18,900	
Diversion, canal, dykes, etc.		$26.600
TOTALS	$23.047	$69.745

Subjugation Costs	$23.047*
Balance	$69.745
Total	$92.792

PROPOSED WORK PLAN

In the index the Erosion Control and Water Spreading Projects and Special Erosion Control Projects have been classed

* Agronomy estimate of $23,298 does not include subjugation of Farms 402 and 403, Quad. 7 but does cover Farms 50 and 67, Quad. 14 not in engineering estimate of $23,047 - hence the discrepancy in the two figures.

as critical, semi-critical and secondary. Critical Erosion Control and Water Spreading Projects are very badly over-grazed and serious sheet and gully erosion has begun. Range control is suggested within these critical areas with engineering construction to be started immediately. Critical and semi-critical Special Erosion Control Projects amount to $1,850 exclusive of subjugation costs and should be treated as soon as practical.

Semi-critical Erosion Control and Water Spreading Projects do not need intensive treatment. It may be best to wait until range control allows a recovery in vegetation on the spreading grounds before work is begun with only the series heads treated at present. With an effective stock control program we may expect an appreciable increase in volume and density of vegetation. All water spreading will then be proportionally more effective and danger from gullying at the lower end of the spreading ground will be materially decreased.

Concerning the agricultural developments, those on Cards #12, #17, #41, and #42 have been given priority or Feasibility Classification A, while those on Cards #6 and #23 are given Classification B. As mentioned under the section "Agricultural Developments" we feel that the Wepo Project, Card #17 and the Polacca Project, Card #41, are quite practical and should be given very consideration. Should the people of Second Mesa need no additional land we feel the Wepo Project should be constructed first; however, if there is a definite need for additional agricultural land at both First Mesa and Second Mesa, a rather intensive and detailed survey may be necessary to determine which project should be considered first.

If heavy equipment is available, the Polacca Project may be more feasible, particularly if it appears that expansion of agricultural lands will become imperative in the future. A great many factors enter into the respective merits of these two projects, and careful consideration should be given them both.

Concerning the other two A agricultural projects, Taylor Springs, Card #42 and Farm #153, Card #12, immediate work should begin on Farm #153. This is very critical and must be started at once. Taylor Springs Project is discussed under "Agricultural Developments".

Before construction begins, topographic surveys will be needed on Cards #2, #6, #12, #17, #23, #26, "27, #41 and #42. A rather detailed reconnaissance has been made of the

various possibilities and it is hoped our estimates are not more than 10% to 15% off.

An outline of the proposed work plan is given below:

I. Immediate treatment: Cards #2, #12, #5A, #29, #35, #36, #37, #38 and #22.

II. Secondary treatment on semi-critical Special Erosion Control Projects and those portions of semi-critical Erosion Control and Water Spreading Projects where better spreading ground is available and serious heads found.

III. Immediate and careful consideration of Agricultural Developments shown on Cards #17, #41, #42 with secondary consideration of Cards #6 and #23.

IV. Development of agricultural projects to be considered from long range viewpoint as to future need for agricultural land in that vicinity.

V. Topographic surveys on Cards #2, #6, #12, #17, #23, #27, #41 and #42 before construction begins.

VI. A planned maintanance program to be carried on in conjunction with periodical checks of new erosion concentrations and careful observations made as to range recovery and gully heading as affecting projects which may develop.

VII. Immediate erosion control along trails and roads and a sound policy of road construction with carefully planned drainage structures and erosion protection features.

INDEX AND MAPS

The index should be self-explanatory, all projects having been given a separate card with each card numbered.

Following the cost summary on page 25 to 31 are sketches 1, sketches 2, 3, 4, and 5 on pages 32, 33, 34, and 35. On the 1" to the mile engineering overlay the projects are outlined with card number and project number given.

All of the other divisions have given their full co-operation in both the field and office toward the prepa-

ration of this report. Particular credit is due the soil, range and agronomy representatives for their help in choosing the various projects suggested.

Submitted by: Allan Stamm

Engineering Aide.

COST SUMMARY, PROPOSED PROJECTS L.M.U. #6 Sub-Unit 1

Card. No.	Quad. No.	Project No.	Acres	Cost per Acre	Cost Erosion Control	Cost Water Spreading	Cost Subjugation	Priority	Description of Project
4	14	E.C. & W.S. Project 1	14-F 1350-R	$15 40¢	$ 210 270	$ 270		Semi-critical	Control 2'-5' Heads & bullies & protection Farms #31, #32, #33.
5	14	EC. & W.S. Project 2	4,700-R	30¢	$ 705	$ 705		Semi-Critical	Scattered & varied treatment with small dykes, checks, spreaders.
13	14	E.C. & W.S. Project 5	7,350-R	30¢	$1,100	$1,100	-	Semi-Critical	Rather intensive treatment with earth horseshoe dykes, spreaders, gully plugs, etc.
14	14	E.C. & W.S. Project 6	3,200-R 300-G	20¢ $1.50	$545	$ 545	- -	Semi-critical	Intensive treatment over grassland near tank M-43 & scattered treatment over balance.
15	14	E.C. & W.S. Project 7	13,500-R	15¢	$1,015	$1,010	-	Semi-Critical	1½' - 3'. Heads over most of this area. Treatment rock & brush checks & small earth dykes.
3	13	E.C. & W.S. Project 1	7,400-R	15¢	$ 550	$ 550	-	Secondary	15'-300'. Spreaders & 2000 yds. earthwork. Has been turned in a part of E.C. #1. Unit 4.
8	14	E.C. & W.S. Project 3	4,250-R	10¢	$ 215	$ 210	-	Secondary	Very scattered treatment along northwest side Polacca Wash.
11	14	E.C. & W.S. Project 4	14,000-R	10¢	$ 700	$ 700	-	Secondary	Small scattered structures near mesa top. Rock checks & drops & earth horseshoe dykes.
TOTALS			14-F 300-G 55750-R		$5,310	$5,090			

E.C. - Erosion Control
W.S. - Water spreading
Exp. - Expansion

F - Farmed
R - Range
G - Grassland

COST SUMMARY, PROPOSED PROJECTS L.M.U. #6 Sub-Unit 1

Card. No.	Quad. No.	Project No.	Acres	Cost per Acre	Cost Erosion Control	Cost Water Spreading	Cost Subjugation	Priority	Description of Project
2	13	Special E.C. Project 1	60-Farm	$ 8.00	$ 480	-	-	Critical	Head protection Farm #51. Has been turned in as Card #70, Unit 4.
10	14	Special E.C. Project 3	30-Farm	$26.00	$ 120	$ 120	$ 540	Semi-critical	Development Farm #99 and dykes as head protection below.
1	13	Special E.C. Project 1	4-Orchard	$22.50	$ 90			Secondary	Jetty to protect school orchard at Keam's Canyon Agency.
7	14	Special E.C. Project 1	25 Grass	$12.00	$ 150	$ 150		Secondary	1000' Dyke around head cutting on east side Polacca to protect 25 A. grassland.
9	14	Special E.C. Project 2	6-Exp. 6-Farm	$38.90	$ 235	$ 235		Secondary	Defer until later date. After observing & subjugation will handle water. Farm #155
TOTALS			6-Exp. 25-Grass 4-Orch-96-Farm.		$1,075	$ 505	$ 540		
12	14	Agri. Develop. #2	155Farm. 50-Exp.	$25.70	$1900.	$ 300	$3075	A	Development & erosion control on Farm #153. Drop structure to save highway, farm and range land.
6	14	Agri. Develop.#1	165-Far. 65-Exp.	$18.80	$2,020 - Diversions and Dykes		$2475	B	See Sketch 1. Development of farms #48 & #54 & 65 Acres of expansion
17	14	Wepo Proj. Ag.Devel.3	205-F 100-Exp.	$40.00	$5020-Diversion& Dykes $1500-Sau.Stabil.		$5400	A	See Sketch #2 and Engineering Report.

E.C. - Erosion Control
W.S. - Water Spreading
Exp. - Expansion

(Subjugation Costs Included in Agronomy Report)

COST SUMMARY, PROPOSED PROJECT L.M.U. #6 Sub-Unit 2

Card No.	Quad No.	Project No.	Acres	Cost per Acre	Cost Erosion Control	Cost Water Spreading	Subjugation	Priority	Description of Project
5A	15	E.C. & W.S. Project 1	3400-R	60¢	$1,020	$1,020		Critical	Approx. half cost earth dykes & diversions. Balance checks & drops at head-cutting.
29	7	E.C. & W.S. Project 3	9000-R	49½¢	$2,225	$2,225		Critical	Intensive treatment over entire area with spreader fences and diversion dykes.
28	7	E.C. & W. S. Project 2	1000-R	35¢	$ 175	$ 175		Semi-critical	Three diversion dykes and four spreader fences on small gully.
TOTAL			13,400-R		$3,420	$ 3420			
17A	14	Special E.C. Project 4	24-F	$21.70	$ 200	$ 100	$ 222	Semi-Critical	Development Farms #150 and #149 and diversions to these dams.
26	7	Special E.C. Project 6	175-F	$5.00			$ 875	Semi-Critical	Development Farm #148
27	7	Special E.C. Project 7	130-F 30-Exp.	$ 6.40	$ 150	$ 70	$ 800	Semi-critical	Development of Farm #141 and 3 dykes to stop head-cutting.
24	7	Special E.C. Project 4	850-R	30¢	$ 125	$ 130		Second-ary	Three spreader fences above heads on east side Oraibi.
25	7	Special E.C. Project 5	3-F	33 1/3¢	$100			Second-ary	Two spreaders diverting gully onto Farm #173.
30	7	Special E.C. Project 8	250-R	30¢	$ 75			Second-ary	Special Road Protection. Head-cutting threatening 250 acres.
TOTALS			30-Exp. 1100-R 332-F		$655	$295	$1897		
23	7	Agricultural Devel. #1	50-Exp.	$36	Diversion & dykes	$1050	$ 750	B	Diversion of Wash 2.14 to south allowing expansion of 50 acres.

COST SUMMARY, PROPOSED PROJECTS L.M.U. #6 Sub-Unit 3

Card No.	Quad. No.	Project No.	Acres	Cost per Acre	Cost Erosion Control	Cost Water Spreading	Cost Subjugation	Priority	Description of Project
35	96-7	E.C. & W.S. Project 1	21,500	21¢	$2,250	$2,250		Critical	Scattered treatment over entire area with horseshoe dykes and spreaders.
36	96	E.C. & W.S. Project 2	13,100	22½¢	$1,475	$1,475		Critical	Work concentrated along Saccatone valleys--long spreaders and horseshoe dykes.
37	17 96 16	E.C. & W.S. Project 1	11,200	25¢	$1,400	$1,400		Critical	Intensive treatment dykes & checks of area south & east of Blue Point.
38	16	E.C. & W.S. Project 1	4,700	20¢	$ 470	$ 470		Critical	Horseshoe diversion dykes and water conservation dams.
18	7-97	E.C. & W.S. Project 1	2,300	40¢	$ 460	$ 460		Semi-critical	Dyke around 5' head near middle of project and several spreaders along valley floor.
TOTAL			52,800		$6,055	$ 6.055			
22	7	Special E.C. Project 3	New Sch. Oraibi		$ 150			Critical	Three lines of windbreaks 300' long - Total - 900 feet.
19	7	Special E.C. Project 1	30-F	$21	$ 100	$ 80	$ 450	Semi-critical	Development Farm #151
31	7	Special E.C. Project 9	16-F	$11.50	$ 105	$	$ 80	Semi-critical	Development Farm #398 and protection dykes to protect head erosion.
33	7	Special E.C. Project 11	18-F	$14.70	$ 175		$ 90	Semi-critical	Development Farm #377 & #378 and dykes control head-cutting.
20	7	Special E.C. Project 2	34-F	$12.60	$ 110	$ 110	$ 210	Secondary	Development Farm #153 and #156 and protection dykes from head-cutting below.

IV

COST SUMMARY PROPOSED PROJECTS L.M.U. #6 Sub-Unit 3

Card No.	Quad. No.	Project No.	Acres	Cost per Acre	Cost Erosion Control	Cost Water Spreading	Cost Subjugation	Priority	Description of Project
32	7	Special E.C. Project 10	350-R	40¢	$100	$ 40		Secondary	Spreader fences above head-cutting threatening 350 acres
34	7	Special E.C. Project 12	600-R	35¢	$105	$ 105		Secondary	Dyke and spreaders to divert water onto spreading ground.
39	16	Special E.C. Project 1	80-F	$5			$ 400	Secondary	Development Farm #1 by construction 6 - 600' spreaders.
40	16	Special E.C. Project #2	1-F 50-R	$20	$ 60	$ 60		Secondary	Two dykes to divert water from heads on east side of Polacca to south.
TOTALS			179-F	$905	$395	$ 1,230			
41	15 14 16	Polacca Pro.	3140		Diver. dykes& spreaders -$13,310	$7,200	A		Sub-Unit Two. See Sketch No. 4
42	14	Taylor Spgs. Project	8-10		Pipe-line& Reservoir -$1500	-	A		Sub-Unit One. See Sketch No. 5
21	7			Semi-stabilized heads below forms and range					Investigate again in 5 years.
16	14			" " " " " "					Investigate again in 5 years.

5

PROJECTS WITHIN P. C. #4 AND #5 (Include with Unit 4.)

Card No.	Quad. No.	Project No.	Acres	Cost per Acre	Cost Erosion Control	Cost Water Spreading	Cost Subjugation	Priority	Description of Project
43	7	E.C. & W.S. "A"	820	30¢	$ 120	$ 120		Second-ary	Protection head-cutting from Oraibi at drainage 2.26.
44	10 14	E.C. & W.S. "B"	10,750	40¢	$2,150	$2,150		Semi-critical	These four projects are located on either side of the Oraibi Wash at the north end of the Unit, and are included within P.C. #4, which is in Unit 4. These projects were not surveyed or written up in report on L.M. Unit 4. Treatment will consist of spreaders and dykes along floor of valleys.
45	97 10	E.C. & W.S. "C"	3,900	45¢	$ 875	$ 875		Semi-critical	
46	97 7 10	E.C. & W.S. "D"	3,650	45¢	$ 820	$ 820		Semi-critical	
47	97 7	E.C. & W.S. "E"	4,660	40¢	$ 930	$ 930		Semi-critical	
48	7	Spc. Eros. Cntr."F"	60-F	$11	$ 175		$480	Second-ary	Diversion dyke to divert gully cutting into field to south and spread water on farm.
TOTALS			60-F 23,780-R		$5,070	$4,895	$480		

See following page for additional segregation of estimated costs.

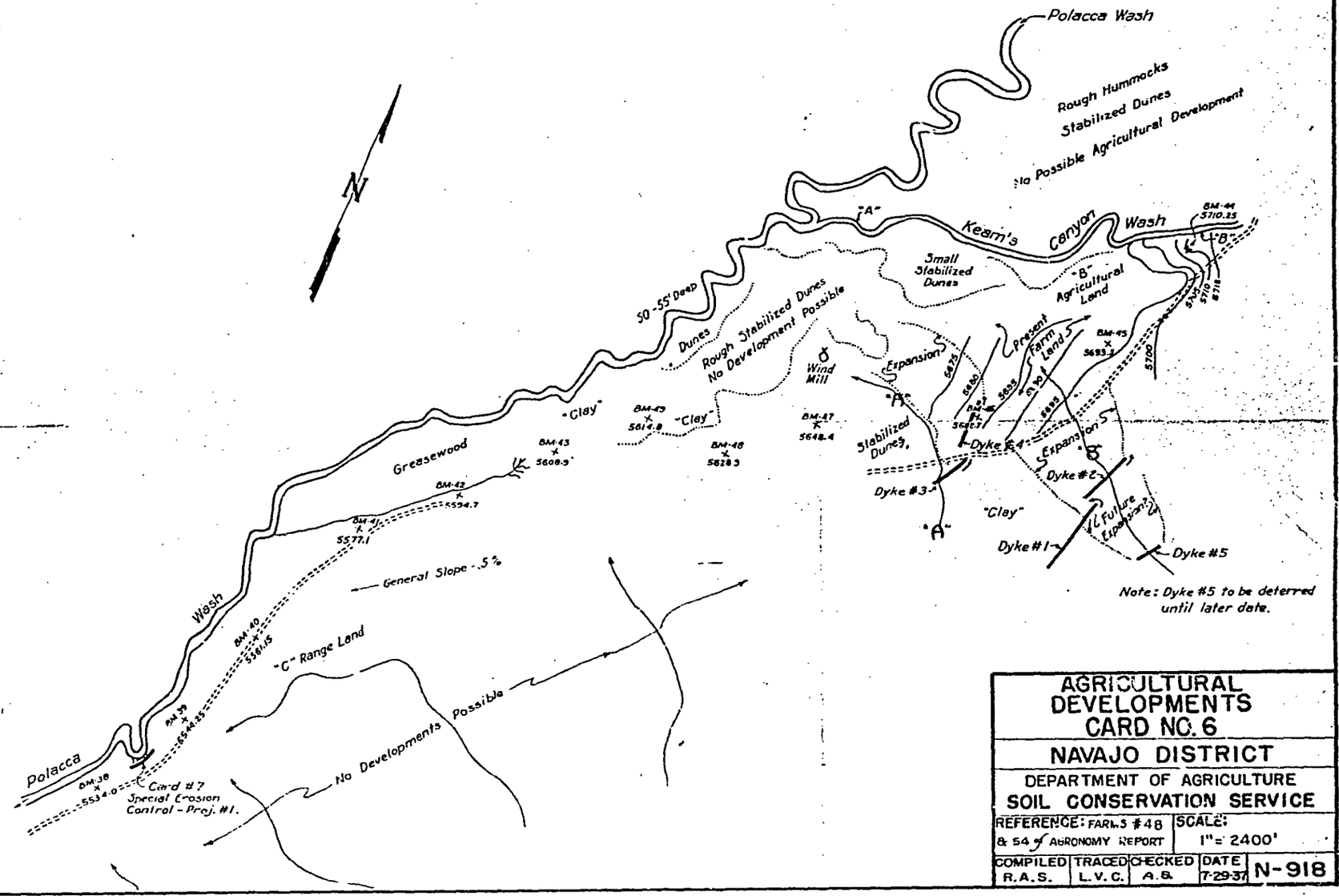
UNM 1371

District	Erosion Control & Water Spreading							Special Erosion Control								Agricultural Developments						Total
	Critical		Semi Critical		Secondary		Total	Critical		Semi Critical		Secondary		Subjug.	Total	See Cards #12, #17, #23, #6, #41, #42						
	Erosion Control	Water Sprd.	Erosion Control	Water Sprd.	Erosion Control	Water Sprd.		Erosion Control	Water Sprd.	Erosion Control	Water Sprd.	Erosion Control	Water Sprd.			Erosion Control	Water Sprd.	Diversions and Dykes	Subjug.	Miscell.	Total	
One			$3845	3630	$1465	$1460	$10,400	$430		$120	$120	$425	$385	540	$2120	$1700	$300	$7040	$10,750	$3,000	$23,190	$35,710
Two	$3245	$3245	$175	$175			$6,840			$350	$170	$305	$125	$1817	$2847			$14,360	$7,950		$22,310	$31,997
Three	$5575	5515	$460	460			$12,1[illegible]	150		$390	80	$815	315	$1230	2530							$14,640
P.C. #4 & 5			$4775	4775	$120	$120	$9,790					$175		$480	$655							10,445
Total	$8840	8840	$9255	9040	$1585	1580	$37,140	$630	--	$850	$390	$1330	825	$4147	$8152	$1700	$300	$21,400	$18,900	$3,000	$45,500	$92,792

Subjugation Costs: $23,047*
Diversions, dykes, erosion control, water spreading, etc. $67,745
Total $92,792

* ~~[illegible]~~ See Bottom Page 21.

SKETCH No. 1
QUAD. No. 14



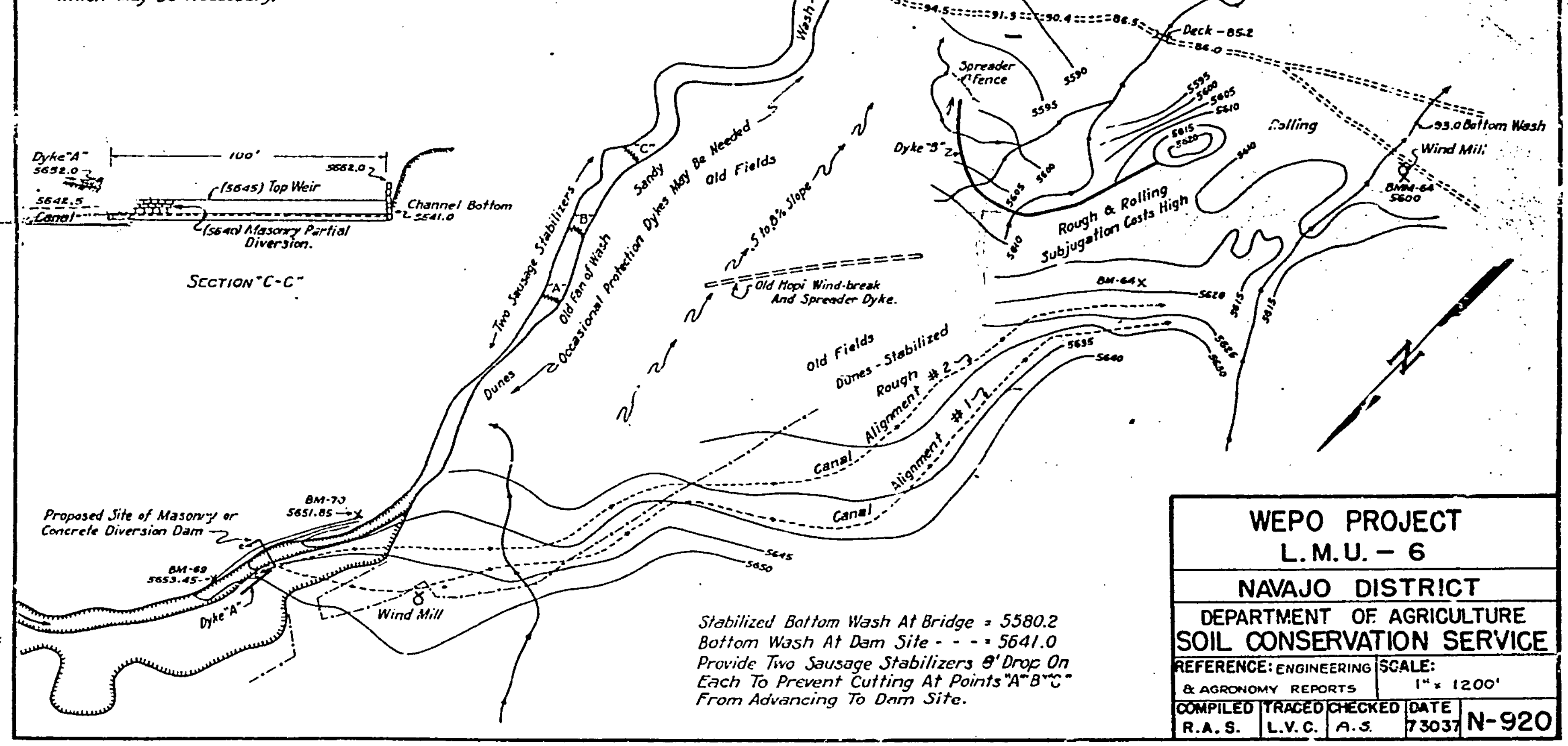
AGRICULTURAL DEVELOPMENTS CARD NO. 6				
NAVAJO DISTRICT				
DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE				
REFERENCE: FARMS #48 & 54 of AGRONOMY REPORT		SCALE: 1" = 2400'		
COMPILED	TRACED	CHECKED	DATE	N-918
R.A.S.	L.V.C.	A.S.	7-29-37	

Sketch No. 2
Quad. No. 14

Cost Estimate – Wepo Project

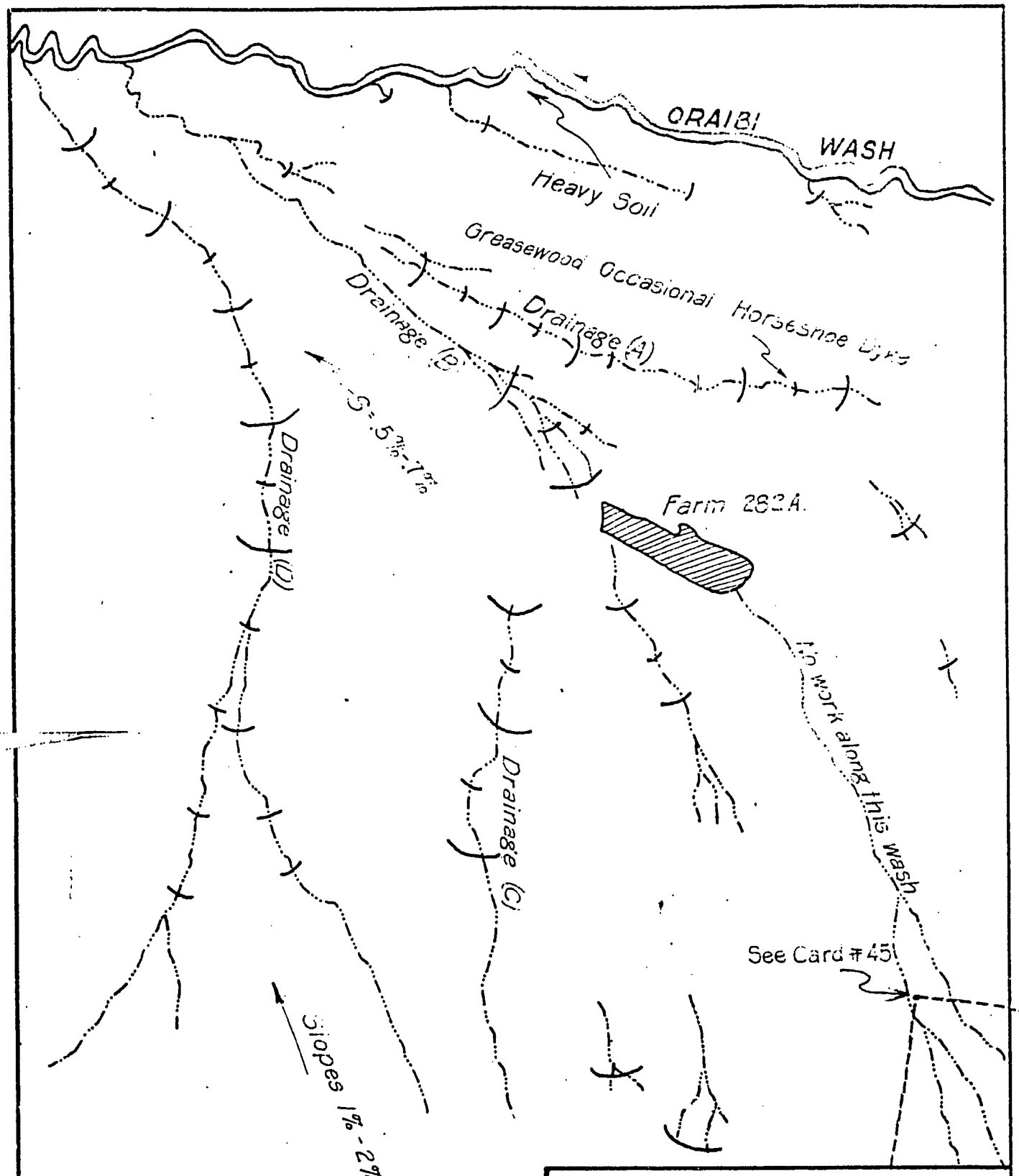
Masonry - Partial Diversion Dam	234 yd.	@ $3.50	$820.00
Gunite Placing	175 □ yd.		100.00
Dyke "A"	2500 yd.	@ .20	500.00
Riprapping			500.00
Two Sausage Stabilizers			1,500.00
Canal 0+00 - 108+00	10,000 yd.	@ .20	2,000.00
Dyke "B"	3,000 yd.	@ .20	600.00
Dykes Along Edge of Wash			500.00
Subjugation - 300 Acres		@ 18.00	5 400.00
Total Cost			$11,920.00*

*This Does Not Include Turnouts Or Sluice-gate Which May Be Necessary.



Stabilized Bottom Wash At Bridge = 5580.2
Bottom Wash At Dam Site - - - = 5641.0
Provide Two Sausage Stabilizers 8' Drop On Each To Prevent Cutting At Points "A" "B" "C" From Advancing To Dam Site.

WEPO PROJECT L.M.U. – 6				
NAVAJO DISTRICT				
DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE				
REFERENCE: ENGINEERING & AGRONOMY REPORTS			SCALE: 1" = 1200'	
COMPILED R.A.S.	TRACED L.V.C.	CHECKED A.S.	DATE 73037	N-920



LAND MANAGEMENT UNIT 6
SKETCH NO. 3 CARD 29

NAVAJO DISTRICT
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

REFERENCE	SCALE
Engineering Report.	1"=2400'

COMPILED	DRAWN	CHECKED	DATE
Stamm	Stamm	Stamm	7-37 L-941

UNM 1374

POTENTIAL ACERAGE UNDER PROJECT

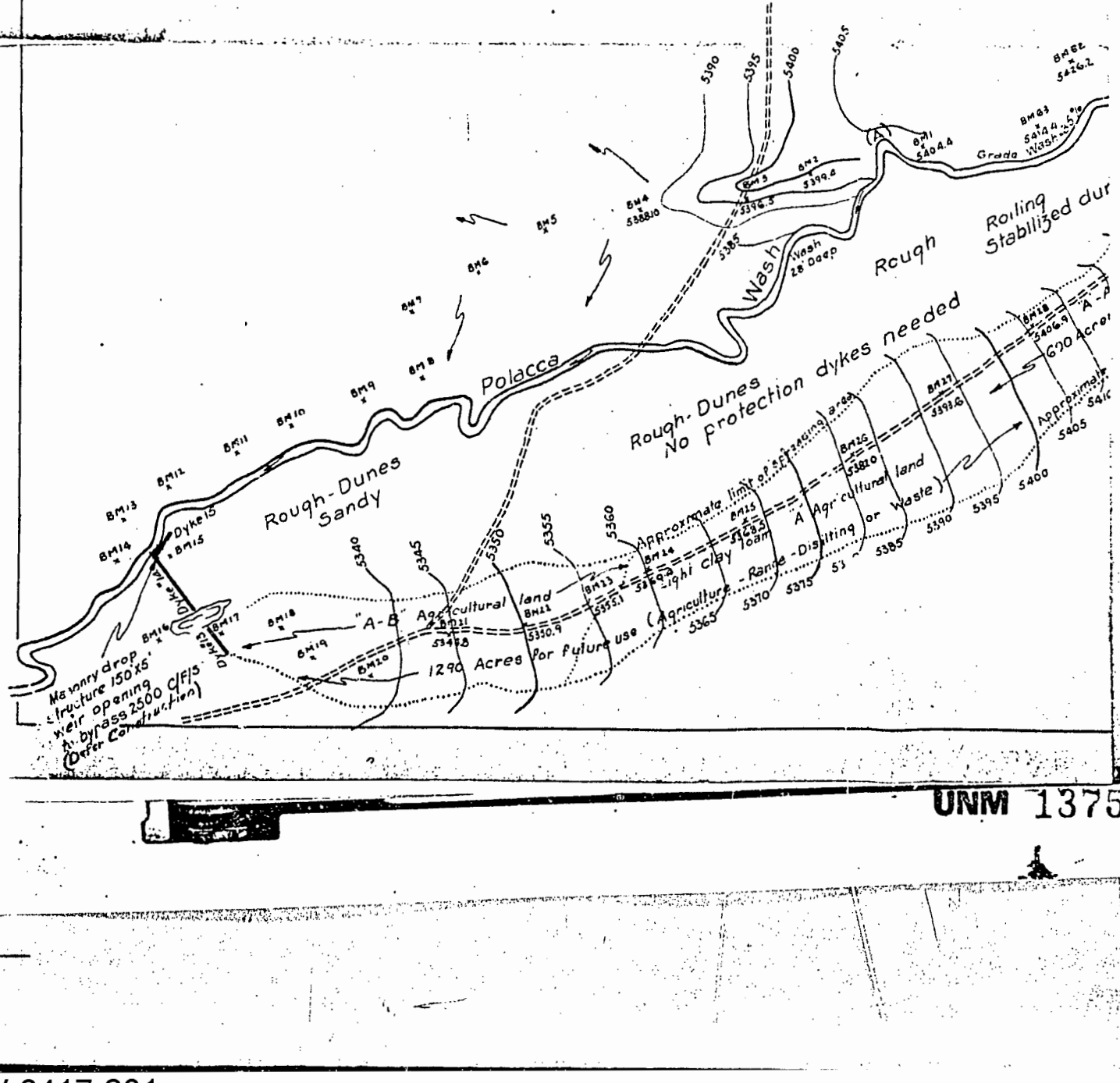
Desilting - 750 acres clay
Hayland - 500 acres clay
Agricultural land - 600 acres light clay loam to be subjugated
Balance - 1290 acres light clay loam.
Total - 3140 acres. Additional land is a safety factor which may comprise agricultural, range, desilting and waste portions of the project

1- 500 ac
2- 600 ac

Also 1290
agriculture,

COST ESTIMATE

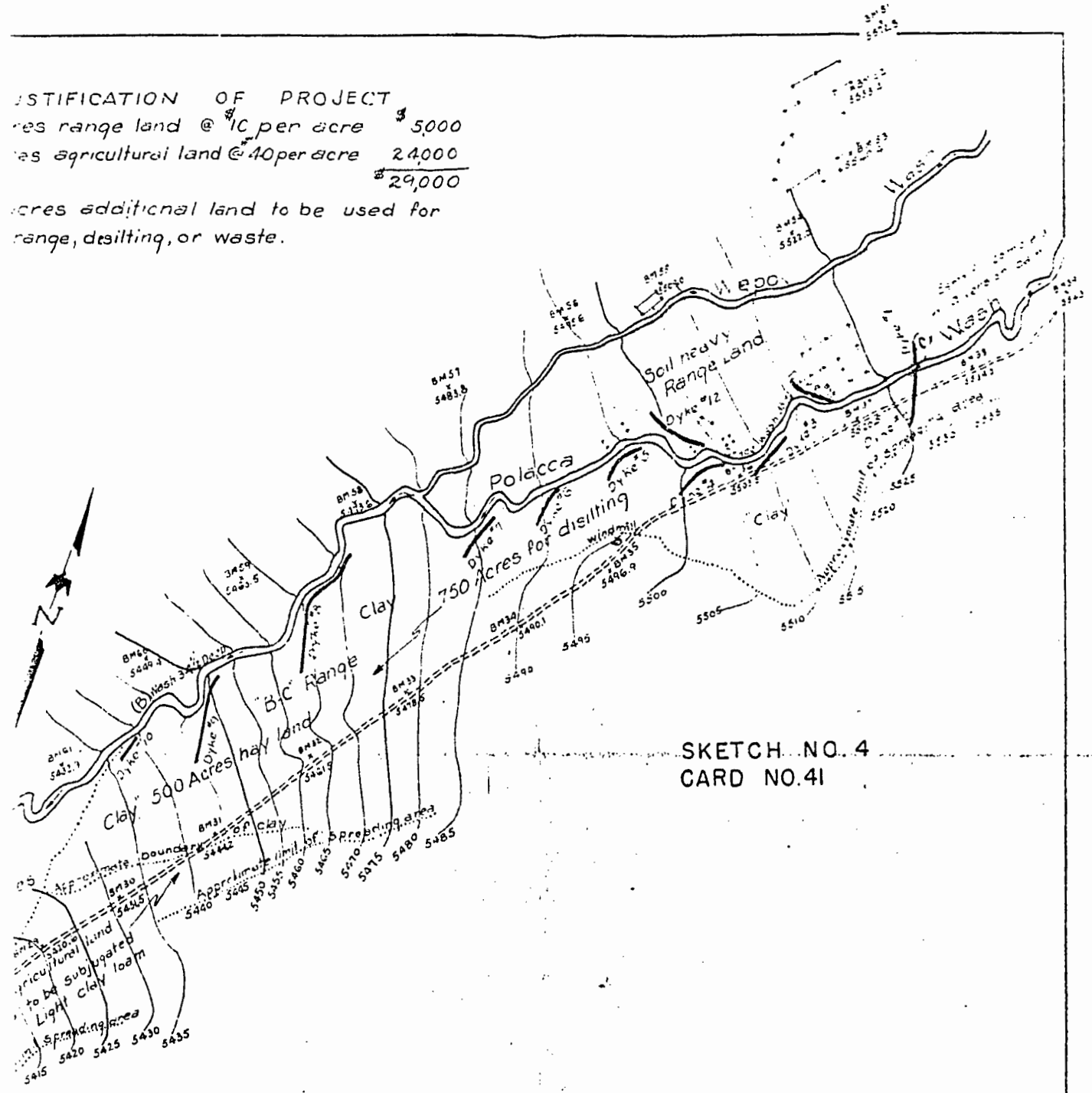
Complete diversion dam, earthfill - 23,000 yds @ 20¢	= $4,600
Breaking banks, possible corewall, riprapping, etc	= 1,400
Dyke #1 & dyke #2 11,000 yds. @ 20¢	= 2,200
Dykes #3, #4, #5, #6, #7, #8, #9, #10, #11, & #12 - 18,500 yds @ 20¢	= 3,700
Rock & wire protection on end of dykes - 22 needed	= 630
10 rock & wire stabilizers 222 yds @ $3.50	= 780
Masonry drop structure & dykes #13, #14, & #15 (Defer Construction)	= (8,550)
	$ 21,860
Subjugation 600 acres @ $12 per acre	= 7,200
Total cost	$29,060 less (8,550)
	= $20,510



JSTIFICATION OF PROJECT

res range land @ $1C per acre $ 5,000
as agricultural land @ $40 per acre 24,000
$29,000

cres additional land to be used for
range, desilting, or waste.



SKETCH NO. 4
CARD NO. 41

POLACCA PROJECT
LAND MANAGEMENT UNIT 6

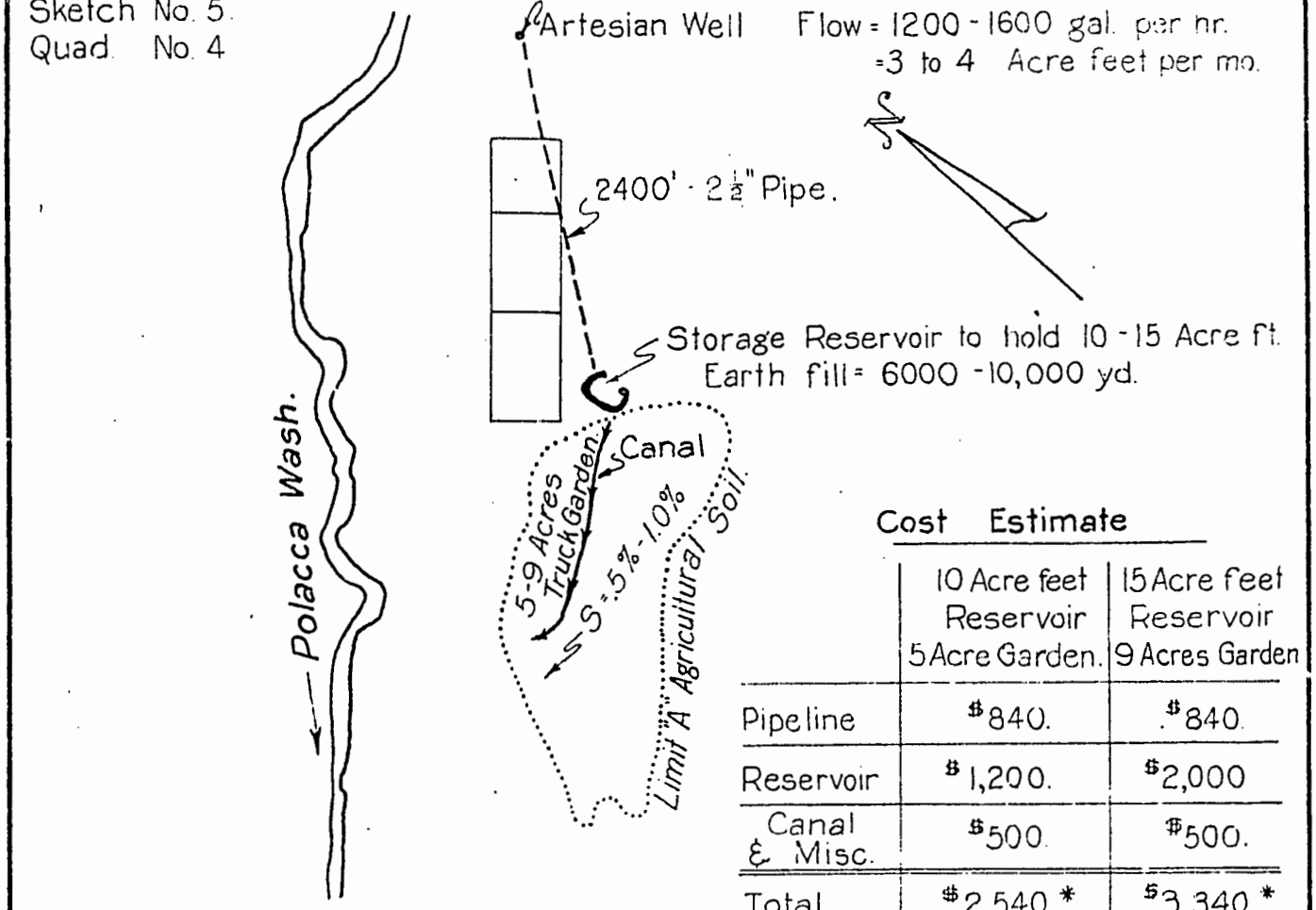
NAVAJO DISTRICT

DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

REFERENCE. AERIAL MOASIC COTACT PRINTS & ENG. MAP & REPORT L.M.U. 6			SCALE '1"=2400'	
COMPILED STAMM	TRACED T.E.D.	CHECKED STAMM	DATE 8-2-37	0-923

UNM 1376

Sketch No. 5.
Quad. No. 4



Cost Estimate

	10 Acre feet Reservoir 5 Acre Garden.	15 Acre feet Reservoir 9 Acres Garden
Pipeline	$840.	$840.
Reservoir	$1,200.	$2,000
Canal & Misc.	$500.	$500.
Total	$2,540. *	$3,340 *
Cost Per Acre	$508	$370

* Probable that actual material costs will not exceed $1,500. for donated teamwork on reservoir and hand labor can be secured.

Month	SUPPLY A FEET	STOCK WATER	EVAP. & LOSSES	IRRIG. 5 ACRES	NET TO RESER	ON HAND PREV. MO.	TOTAL END MONTH
Flow 3 A.F. Per Month							
JAN.	3	.2	1.2	0	1.6	4.8	6.4
FEB.	3	.2	1.2	0	1.6	6.4	8.0
MAR.	3	.2	1.2	0	1.6	8.0	9.6
APR.	3	.2	1.5	1.5	- .2	9.6	9.4
MAY	3	.2	2.1	2.5	-1.8	9.4	7.6
JUNE	3	.2	2.5	3.0	-2.7	7.6	4.9
JULY	3	.2	2.5	3.0	-2.7	4.9	2.2
AUG.	3	.2	2.3	2.5	-2.0	2.2	.2
SEPT.	3	.2	1.5	1.5	-0.2	.2	.0
OCT.	3	.2	1.2	.0	1.6	0	1.6
NOV.	3	.2	1.2	0	1.6	1.6	3.2
DEC.	3	.2	1.2	0	1.6	3.2	4.8
Flow 4 A.F. Per Month							
JAN.	4	.2	1.3	**0	2.5	7.5	10.0
FEB.	4	.2	1.3	0	2.5	10.0	12.5
MAR.	4	.2	1.3	0	2.5	12.5	15.0
APR.	4	.2	1.6	2.6	- .4	15.0	14.6
MAY	4	.2	2.2	4.4	-2.8	14.6	11.8
JUNE	4	.2	2.6	5.4	-4.2	11.8	7.6
JULY	4	.2	2.6	5.4	-4.2	7.6	3.4
AUG.	4	.2	2.4	4.4	-3.0	3.4	.4
SEPT.	4	.2	1.6	2.6	- .4	.4	0.0
OCT.	4	.2	1.3	.0	2.5	0.	2.5
NOV.	4	.2	1.3	.0	2.5	2.5	5.0
DEC.	4	.2	1.3	.0	2.5	5.0	7.5

All figures are acre feet. Top chart for 5 Ac. truck garden. 10 Acre feet reservoir capacity.
** Lower chart for 9 Ac. truck garden. Reservoir 15 Acre feet

TAYLOR SPRINGS
PROJECT. L.M.U. 6

NAVAJO DISTRICT
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

REFERENCE: Engineering & Soil Report			SCALE 1" = 1,200'	
COMPILED Stamm	TRACED Stamm	CHECKED Stamm	DATE 7-37	L-946